Exploration of the Lesser Antilles, Montserrat & Dominica (NA037)

2013 Cruise Report

State Department File No. F2013-050

Objectives

Volcanic activity in the Lesser Antilles island arc produces large quantities of fragmental material that is being delivered to the shallow and deep marine environments. In particular, the islands of Montserrat and Dominica have been the source of massive discharges of volcanic material into the sea. Relatively little is known about the direct impacts of this process on the marine biological communities and the formation of submarine geological deposits. On Montserrat, the Soufriere Hills volcano has been erupting since 1995 leading to evacuation of most of the southern part of the island. About 1 km^3 of andesite magma has been erupted and much of this material has ended up in the ocean in the form of volcanic ash and debris, mostly through the mechanism of large collapses of the lava dome often accompanied by explosions. The volcanic events also included a devastating volcanic blast on 26th December 1997 that affected the west flanks of the volcano and razed two villages to the ground, sweeping the houses, their contents, and other objects such as trucks and tractors, into the sea.

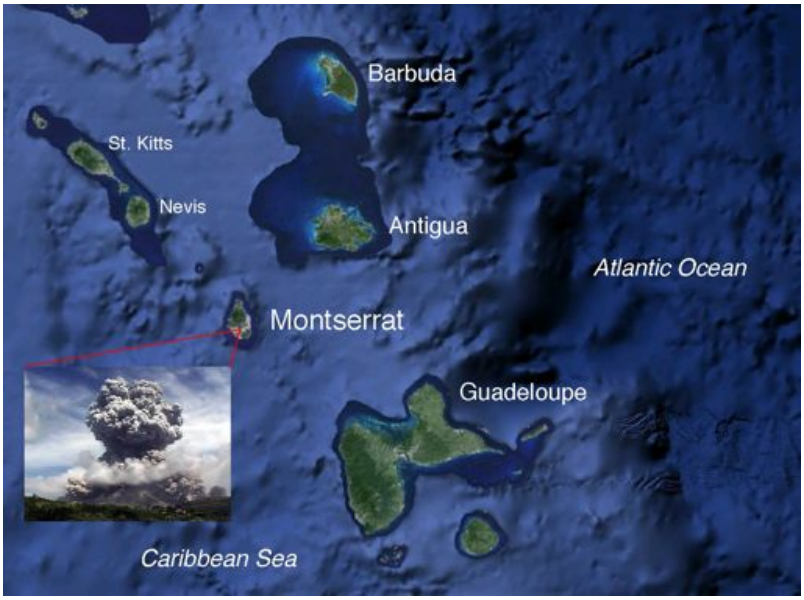
These events provide a remarkable opportunity for the application of state-of-the-art ocean exploration techniques to understand the dynamics of pyroclastic flows that are discharged into the ocean and their effects on the marine environment. The E/V *Nautilus* used multibeam sonar surveys and remotely operated vehicles (ROVs) to investigate the area to the southwest, south, and east of Montserrat where volcanic material has entered the sea. In addition, the nature of several unexplored submarine volcanoes southeast and southwest of the Montserrat was investigated by ROV exploration. In the area of Dominica, previous work had identified the occurrence of at least three debris avalanche deposits in the Grenada Basin that have formed by large scale collapse of the island flanks. These collapses have led to the creation of a highly irregular seafloor dominated by megablocks up to several hundred meters in diameter. E/V *Nautilus* explored the blocks and collected samples using ROVs in order to obtain information about the timing of the collapse events and their specific source areas on Dominica.

Mapping and CHIRP sonar work had previously been conducted off the west coast of Montserrat to define the entrance of pyroclastic flows into the sea from the Soufriere Hills volcano (Hart et al., 2004) and the evolution of the submarine geomorphology (LeFriant et al., 2004). These data sets were compared with pre-eruption bathymetric data in order to identify areas of recent deposition and erosion. Deposition off the Tar and White River valleys was thickest nearest the coastline and deltas, and extended into deeper water up to 5 km from shore. The total volume of submarine pyroclastic deposits as of July 1998 was 73 x 10^6 m^3 DRE.

Submarine pyroclastic deposits off the Tar River valley made up more than two thirds of the total volume (55 x 10^6 m^3 DRE) and covered an area of approximately 5.0 km^2, which included the delta. The volume of submarine pyroclastic deposits in the White River area (18 x 10^6 m^3 DRE) is probably underestimated due to the lack of precise pre-eruption bathymetric data in areas greater than 2 km from shore. In addition, Trofimovs et al. (2006) collected core samples of the submarine pyroclastic flow deposits and determined that fine-grained material from the flows transformed into turbidity currents that traveled over 30 kms from the east coast of Montserrat. Offshore of Dominica, multibeam mapping and seismic profiling identified multiple debris avalanches resulting from collapse of the islands western flanks (DePlus et al., 2001). The debris avalanches were recognized based on their distinctive hummocky topography and hyperbolic reflections from 3.5 kHz echosounder data. In the Grenada basin the extent of deposits associated with collapses from Dominica is estimated at 3500 km^2. No ROV explorations of this area had been previously undertaken.

Preliminary Results

Montserrat

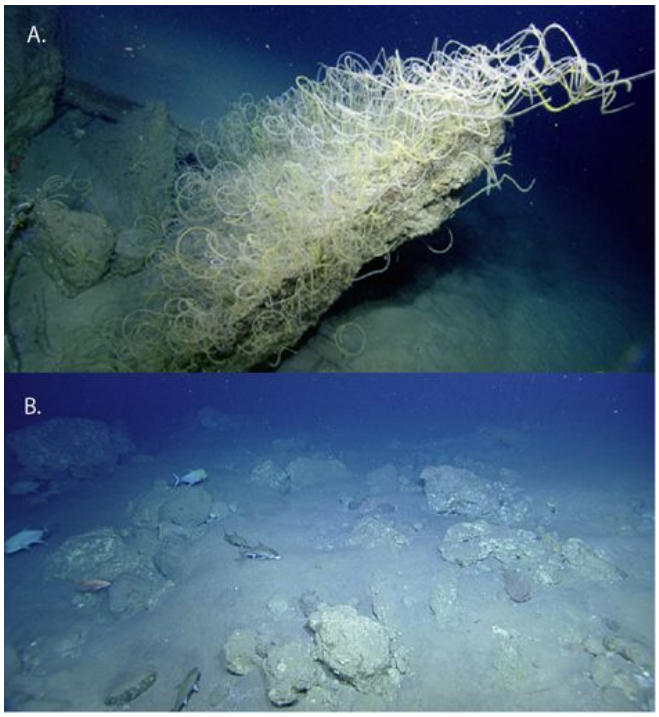


Volcanic activity in the Lesser Antilles island arc (West Indies) produces large quantities of ash, pumice, and rock that are delivered to the shallow and deep marine environments of the western Caribbean Sea and eastern Atlantic Ocean. On the island of Montserrat, in the northern part of the Lesser Antilles, the Soufrière Hills volcano has erupted frequently since 1995 (Figure 1). About 1.1 km^3 of andesitic magma (Wadge et al., 2010) has been erupted, and much of this material has been transported into the ocean as pyroclastic flows—hot avalanches of rocks, ash, and gas that travel at speeds in excess of 160 km per hour (Wadge et al., in press). In addition, mud flows (lahars) carrying volcanic debris wash into the ocean during periods of intense rain.

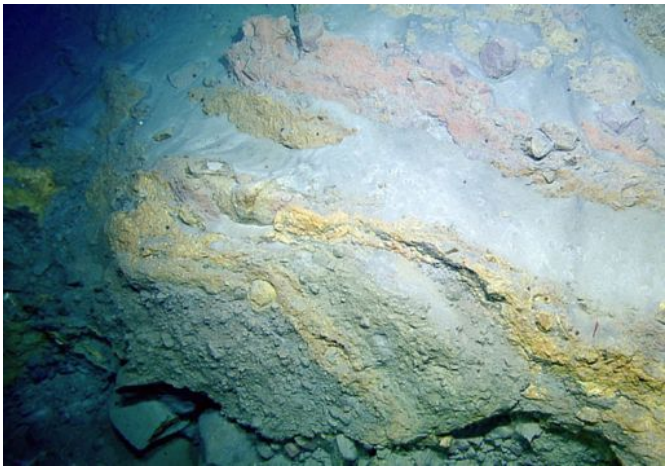
High-resolution bathymetric mapping around Montserrat revealed the importance of volcanic collapses that generate large landslides, known as debris avalanches, as a critical mechanism for transporting large amounts of volcanic material into the marine environment (Deplus et al., 2001; Lebas et al., 2011). Debris avalanches can trigger significant tsunamis, and contribute to the geological hazards associated with this dynamic boundary.

The current volcanic episode includes an eruption on December 26, 1997, that devastated the

southwest flanks of Soufrière Hills volcano and razed two villages, sweeping the houses and their contents into the sea. E/V *Nautilus* investigated the effects of both the recent influx of volcanic material into the sea from the eruption and larger debris avalanche events that took place in the recent geologic past. Effects from discharge of volcanic flows into the sea were found to be localized and related to the flows' intensity and concentration. A major dome collapse (the largest of any historical dome collapse worldwide) in July 2003 initiated a submarine pyroclastic flow (Trofimovs et al., 2006). Observations of carbonate shelf blocks on the surface of these deposits indicate that the shelf was also destabilized by this event.

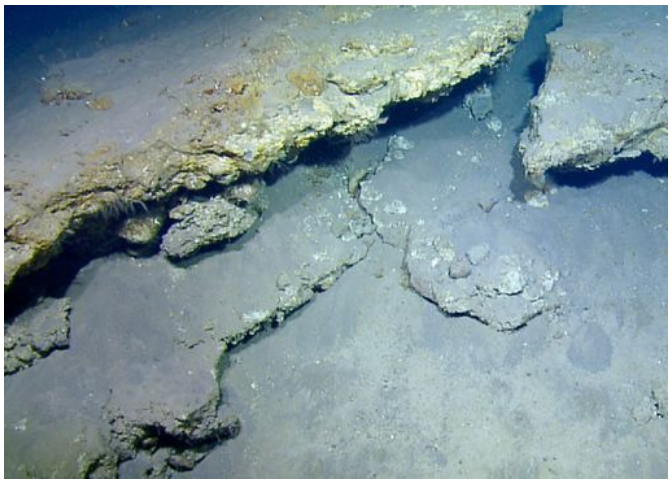


In the area offshore of St. Patrick's village, which was destroyed by the 1997 eruption, few effects could be seen in shallow water (100–200 m). Dense colonies of whip corals (Stichopathes sp.) occupy the marine slopes, indicating that volcanic flows had little impact just offshore of the village despite the devastating effect on land (Figure 2a). It is likely that the energetic flows were too dilute to form high-concentration flows that continued downslope into the marine environment. In contrast, only a few hundred meters along the coast toward the capital city of Plymouth, the shallow seafloor has been swept clean of most marine organisms. They have been replaced by coarse deposits of volcanic ash and boulders (Figure 2b), and repeated lahar deposits over the last 18 years have formed a significant shallow-water deltaic fan. These observations may offer insight into rates of recovery of marine ecosystems as deep as 1,000 m following extreme geological disturbances.



Previous work identified at least five major debris avalanches around Montserrat, although the ages and sources are poorly constrained (Le Friant et al., 2004). ROV dives focused on sampling and observing individual blocks in the deposits to facilitate correlations with landbased sequences and estimation of the units' ages. East of Montserrat, a major debris avalanche (Deposit 1) off the Tar River valley contains some of the largest

blocks found on the seafloor. Samples collected from blocks in this area consisted of hornblende-bearing andesite lava typical of the Soufrière Hills volcanic center, hydrothermally altered volcanic rocks, and moderate numbers of carbonate blocks (Figure 3). Exposures on the steep megablock faces show characteristics typical of debris avalanches, with a chaotic mixture of different rock types and domains of intact stratigraphic sequences from the original volcano. The diversity of rock types in Deposit 1 blocks suggest that the collapse originated from a dominantly subaerial volcanic source, but also included parts of the shallow carbonate platform surrounding the island. A possible origin site of this deposit is English's Crater, a large collapse scar in the Soufrière Hills.



In contrast, exploration of blocks in debris avalanche Deposit 5, located to the southwest of Montserrat, revealed sources mainly on the shallow submarine shelf of the island. These blocks contain abundant indurated carbonate rocks displaying karst solution features typical of subaerial weathering and bedded units with highly rounded volcanic boulders and cobbles typical of deposits emplaced in the high-wave-energy coastal zone or derived from discharge of lahars into the sea. These observations support the interpretation of Deposit 5 by Cassidy et al. (2013) as related to large-scale collapse of the southwestern submarine flank of Montserrat 8,000 to 12,000 years ago. A significant discovery of the exploration was the pervasive development of carbonate hard grounds on the western flanks of the volcano at 150–400 m water depth (Figure 4).

Dominica

Offshore of the island of Dominica lie the largest debris avalanche deposits yet discovered in the Lesser Antilles volcanic arc (DePlus et al.,2001). An ROV dive was carried out on targeted debris avalanche blocks off the west coast of Dominica in the Grenada Basin. The blocks were found to be heavily sedimented with no visible exposures of their interiors , as was common in the areas off of Montserrat to the north. A single sample of a loose rock collected in the area of the debris avalanche blocks consists of a highly-evolved dacite lava, typical of the erupted products of the large volcanic centers on Dominica.

Operations

Seafloor Mapping

Approximately 1,455 km^2 of seafloor was mapped using Nautilus' EM-302 multibeam sonar system. See map below.

ROV Lowerings

During cruise NA037, we conducted five ROV dives, with a total of 90.25 hours in the water, and 79.25 hours on the seafloor (88% of time in water was on the seafloor). The longest dive, H1309, was 26 hours long, and the shortest, H1310, lasted 7.5 hours.

H1308 - *Hercules* & *Argus*

Dive STARTED	2013/10/21	17:48:03	16˚43.130951' N, 062˚03.284027' W
Dive ENDED	2013/10/22	19:41:35	16˚43.816061' N, 062˚07.719222' W

H1309 - *Hercules* & *Argus*

Dive STARTED	2013/10/23	16:12:39	16˚39.389350' N, 062˚15.939730' W
Dive ENDED	2013/10/24	18:14:37	16˚42.193608' N, 062˚14.548403' W

H1310 - *Hercules* & *Argus*

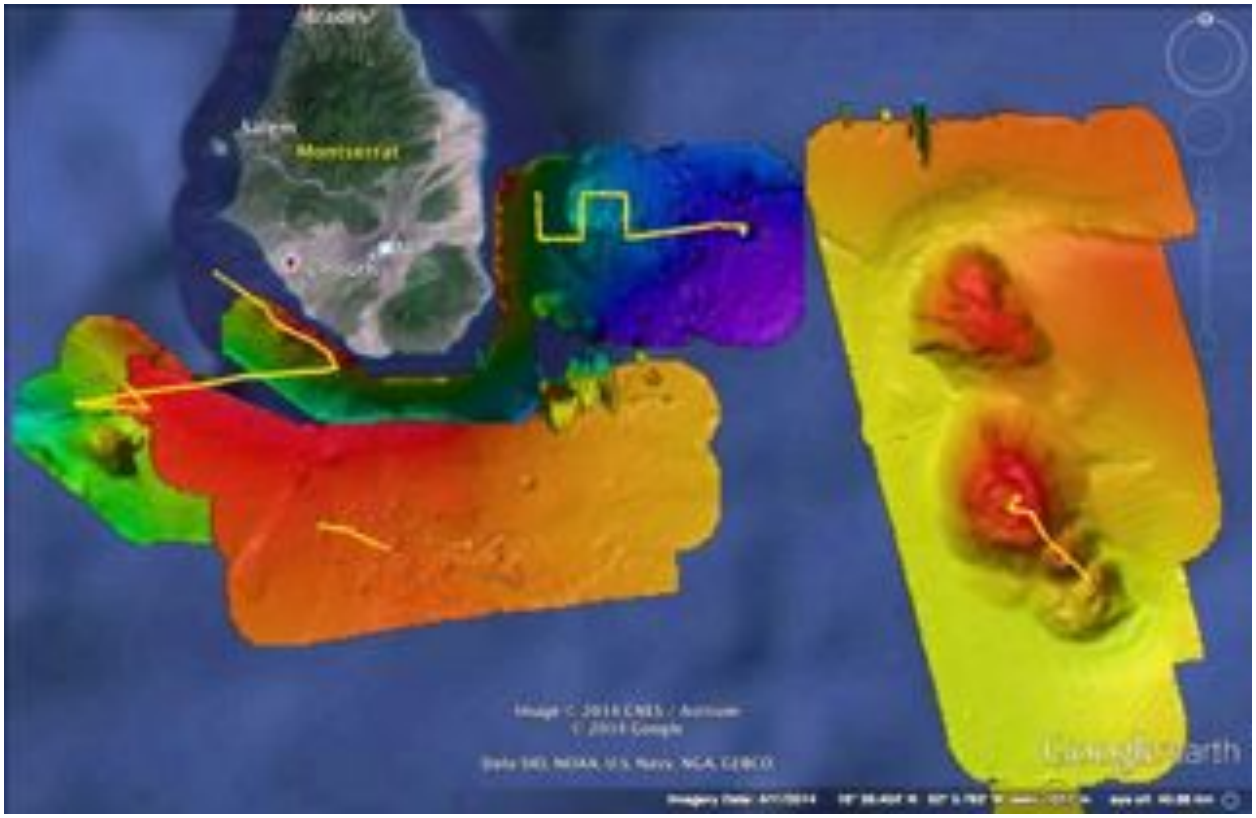
Dive STARTED	2013/10/24	20:29:40	16˚36.567090' N, 062˚10.898970' W
Dive ENDED	2013/10/25	03:59:52	16˚37.020750' N, 062˚12.427770' W

H1311 - *Hercules* & *Argus*

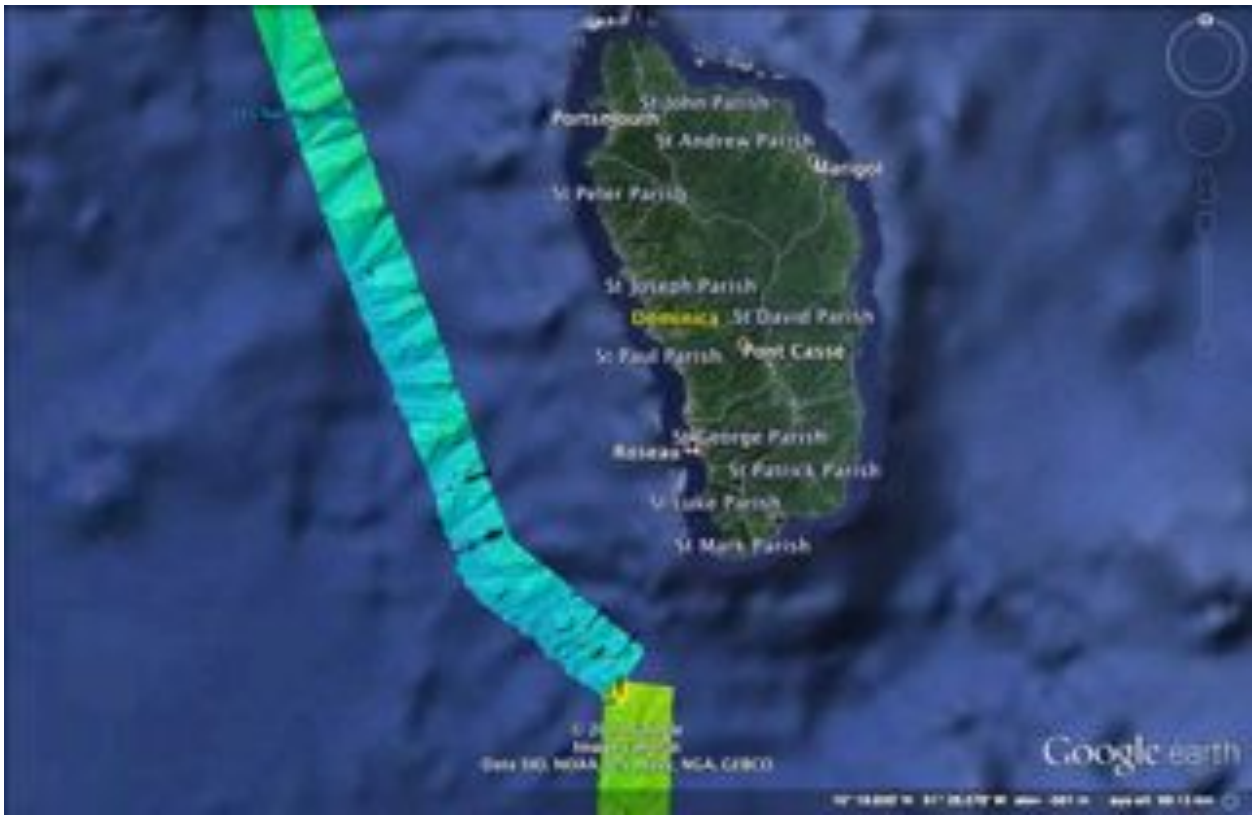
Dive STARTED	2013/10/26	17:00:56	16˚35.969757' N, 061˚55.901673' W
Dive ENDED	2013/10/27	13:34:00	16˚37.537451' N, 061˚57.460952' W

H1312 - *Hercules* & *Argus*

Dive STARTED	2013/10/28	02:09:18	15˚05.49399' N, 061˚26.78381' W
Dive ENDED	2013/10/28	12:26:57	15˚06.17736' N, 061˚26.99243' W



Map showing the locations of multibeam mapping operations and ROV dives (orange lines) around Montserrat.



Map showing the locations of multibeam mapping operations and ROV dive (orange line) around Dominica.

Sampling

Sixty-one geological, biological, and water samples were collected during this cruise.

Geological samples are archived at the University of Rhode Island Marine Geological Samples Laboratory. More information on MGSL and how to request subsamples can be found here: http://www.gso.uri.edu/marine-geological-samples-laboratory

Biological samples are archived at the Harvard University Museum of Comparative Zoology. More information on the MCZ and how to request subsamples can be found here: http://mcz.harvard.edu/collections/index.html

Genomic subsamples of biological samples are archived at the Northeastern University Ocean Genome Legacy. More information on OGL and how to request subsamples can be found here: http://www.northeastern.edu/marinescience/ogl/

Sample ID	Date	Time	Coordinates		Depth
NA037-001-ROVG	2013/10/21	18:57	16˚43.1229'N	062˚03.2973'W	970 m

Angular grey rock, ~10-15 cm wide, 30 cm long, taken at the beginning of the slope block. Dense, grey, hornblende-bearing andesite with some minor red oxidized zones, slightly vesicular, several fractures cut through the outer part of the rock

NA037-002-ROVG	2013/10/21	19:15	16˚43.1221'N	062˚03.3058'W	975 m

Small, round, white rock, ~10 cm. Highly indurated carbonate with coralline fragments and small lithic fragments

NA037-003-ROVG	2013/10/21	22:38	16˚43.1346'N	062˚03.2675'W	952 m

Reddish-grey angular rock from base of debris avalanche. Vesicular hornblende-bearing andesite with same spherulitic texture

NA037-004-ROVG	2013/10/21	23:00	16˚43.1445'N	062˚03.2810'W	942 m

Small, white coated (on top side) round, rock, <10 cm diameter, dark colored. Ferric andesite, abundant small plagioclase, 3-4mm max, small amount of hornblende, subangular clasts with most surfaces relatively fresh, one surface with weathered Mn-crust with small tube organisms growing on weathered side

NA037-005-ROVG	2013/10/21	23:13	16˚43.1424'N	062˚03.2792'W	942 m

White, thin rock, broken from larger block, and broken into smaller pieces upon placement in box. Subtley indurated foram-pteropod-carbonate sediment w. common small volcanic fragments. Exterior has some tubeworm clasts and small core fragments

NA037-006-PC	2013/10/21	23:49	16˚43.1429'N	062˚03.2818'W	936 m

Push core from flat, unrippled area. ~8cm recovered, fine brown silt/mud and coarse clastic black & white sediment layers

NA037-007-ROVG 2013/10/22 01:03 16˚43.1553'N 062˚03.5352'W 1007 m
Outcrop of soft white (crumbly) sediment. Micritic carbonate mud, homogenous, contains somall volcanic crystals within the mud. No banding or other structures observed.

NA037-008-ROVG 2013/10/22 01:40 16˚43.1558'N 062˚03.6546'W 961 m
Grey/white angular rock/sediment. Hornblende andesite, dark grey, abundant hornblendes up to 5-6mm in length. Plagioclase up to 4 mm, dark grey matrix. Highly ferric, angular clasts. Some weathering on opposite faces.

NA037-009-ROVG 2013/10/22 02:16 16˚43.1624'N 062˚03.7252'W 954 m
Yellowish, crumbly hydrothermally altered. Reddish orange, unconsolidated hydrothermally altered clay with cm-sized hydrothermally altered clasts

NA037-010-ROVG 2013/10/22 02:34 16˚43.1617'N 062˚03.7229'W ~960 m
Angular, reddish block (igneous). Red oxidized hornblende andesite, abundant plagioclase red oxidized, ground mass, one side has Mn-coating w. little surface coasting of light calcareous sediment.

NA037-011-ROVG 2013/10/22 03:31 16˚43.1688'N 062˚03.7927'W 987 m
Grey angular andesite block w. some biocrust. Very fresh andesite lava, very similar to young products of Soufriere Hills. Elongate hornblende phenocrysts (1:2-5), abundant plagioclase, phenocrysts and microcrysts, up to ~3mm max, mafic inclusions with sparse plagioclase phenocrysts

NA037-012-ROVG 2013/10/22 10:14 16˚43.8094'N 062˚06.1054'W 840 m
10-cm diameter white (coral?) rock. Bioclastic limestone, small, tube-like things, possible coral structures

NA037-013-SL 2013/10/22 18:15 16˚43.6449'N 062˚07.6622'W 573 m
Yellow material on sediment and base of rock, possibly sulfur oxidizing or reducing bacteria. Subsamples: a. 3.5 mL cryovial (-80 freezer), b: OGL vial #64

NA037-014-PC 2013/10/23 17:13 16˚39.4125'N 062˚16.0157'W 750 m
Sediment core taken in flat, sedimented area at the start of the dive. Sediment is much stickier than last dive area.

NA037-015-ROVG 2013/10/23 17:55 16˚39.4179'N 062˚16.1385'W 755 m
Small rock collected near block in flat sediment area. Small, round, white. ~15 cm. Hornblende andesite pumice, angular.

NA037-016-SL 2013/10/23 18:22 16°39.4147'N 062°16.1397'W 756 m
Strange, round, shiny balls. ~1-2cm diameter. Possibly eggs. Brownish-green in color. Subsamples: a: Several eggs OGL vial # 140; b: Remaining eggs in EtOH

NA037-017-ROVG 2013/10/23 18:58 16°39.4171'N 062°16.2449'W 760 m
Flattish, round rock. Grey on top, reddish underneath. ~10-15 cm x ~10-15 cm. Taken from rocky area. Manganese crust on half the rock, heavily weathered hornblende andesite

NA037-018-PC 2013/10/23 19:28 16°39.4165'N 062°16.2459'W 760 m
Broken push core-turned-sediment-scoop of sediment of possibly volcanic origin. Dark grey, poorly sorted, sandy crystal ash w. cm-ringed pumice fragments, unconsolidated

NA037-019-ROVG 2013/10/23 19:37 16°39.4163'N 062°16.2467'W 759 m
Small roundish rock, reddish and grey in color. ~10-15 cm. Taken from rock outcrop near area w. possible volcanic sediment. Rounded, half manganese crust (black), hornblende/andesite (4 mm hornblende)

NA037-020-ROVG 2013/10/23 20:39 16°39.4404'N 062°16.4749'W 772 m
Bamboo coral from very large carbonate boulder. Possibly Caribisis. Subsamples: a: Several polyps OGL vial #073; b: coral in EtOH

NA037-021-ROVG 2013/10/23 20:50 16°39.4388'N 062°16.4724'W 776 m
Egg-shaped, brown, light-colored, some bio accretion. Well-rounded, hornblende-rich (10%), andesite w. some biogenic growth. Hornblende, small internal plagioclase

NA037-022-ROVG 2013/10/23 20:58 16°39.4388'N 062°16.4724'W 776 m
Carbonate rock, 10 cm across. Weakly consolidated mixed biogenic, volcanic sandstone (>70% volcaniclastic), shell fragment, forams, weakly indurated, some pumices, very poorly sorted.

NA037-023-NB 2013/10/23 22:31 16°39.4712'N 062°16.9248'W 800 m
Water sample for pH

NA037-024-ROVG 2013/10/23 23:26 16°39.4636'N 062°17.0915'W 804 m
Sample from below a rock face: reddish-brown, smooth rock, very soft, broken. Rounded pebble of hornblende andesite w. spinel

NA037-025-ROVG 2013/10/23 23:40 16°39.4697'N 062°17.1064'W 806 m
White rock from base of ridge, round, ~15 cm diameter. Yellow-white bioclastic sandstone w. minor lithic ore crystals (<10%), clasts have carbonate , highly indurated (forams, pteropods), moderately sorted

NA037-026-ROVG 2013/10/24 00:41 16°39.4811'N 062°17.3912'W 823 m
~15 cm, irregular, white carbonate rock w. biogenic growth on outside, rectangular coarse

sandstone w. pebble clasts, mixed biogenic/volcaniclastic (pumic, lithified, shells), poorly sorted and angular fragments. Strongly indurated, maybe some layering 70%/30% volcaniclastic, some clasts coated w. creamy white material. w. 5-8 cm coral fragment

NA037-027-ROVG 2013/10/24 06:16 16˚40.3873'N 062˚12.0613'W 248 m
Small, roundish rock. Brown, pitted, ~20 cm, probably andesite. Slightly vesiculated lava clast w. 3 mm feldspar, coral growth.

NA037-028-ROVG 2013/10/24 06:31 16˚40.3849'N 062˚12.0476'W 243 m
Two urchins, ~10 cm diameter. Found in urchin "horde," on slightly sloped sediment bottom. Small (~1cm) red shrimp also attached. Subsamples: a. Red shrimp OGL Vial #130; b: red shrimp EtOH; c: Whole urchin EtOH; d: Urchin gonads OGL vial # 139

NA037-029-ROVG 2013/10/24 07:52 16˚40.5111'N 062˚12.1067'W 188 m
~15 cm, carbonate matrix w. andesite, brownish color. Broken/fell from edge of scarp. Layered bioclastic/volcaniclastic (abundant bio), vol. Fragments have thin calcareous rim, one layer is fine grained, other is coarse w. volcanic rock fragments. Lots of bio associated (see subsamples). Subsamples: a: Rock; b: cup coral in EtOH; c: branch of coral w. pink polyps, probably scleractinian in EtOH; d: lobsters in OGL vial #121; e: lobsters in EtOH; f: polychaete in EtOH; g: Scallop in EtOH; h: round scleractinian coral in EtOH

NA037-030-NB 2013/10/24 08:45 16˚40.5797'N 062˚12.1739'W 197 m
Water sample from small canyon/chute off St. Patrick's for pH

NA037-031-ROVG 2013/10/24 08:55 16˚40.5706'N 062˚12.1765'W 208 m
Small, ~10 cm, round, brown, rock with fine bio growth from landslide region off St. Patrick's. Well-rounded, weathered andesite (fine grained, mm feldspar), small manganese crust

NA037-032-ROVG 2013/10/24 10:56 16˚40.7931'N 062˚12.4822'W 179 m
Large, 20 cm across, 30 cm tall, white rock, textured. Large reef biotherm. Brittlestar associate. Subsamples: a: rock; b: brittle star in EtOH

NA037-033-ROVG 2013/10/24 13:42 16˚41.2414'N 062˚13.3628'W 292 m
Large carbonate hardpan w. tubeworm casts. Poorly sorted, pebbly sandstone (4cm pebbles, rounded volcanic, rounded matric 50/50 bio/volcanic, pebbles have a white rind, highly indurated, heavily colonized, w. biogenic coating

NA037-034-SL 2013/10/24 13:50 16˚13.3614'N 062˚13.3614'W 292 m
Cob-web like biofilm. In OGL Vial #131

NA037-035-ROVG 2013/10/24 17:37 16˚42.1855'N 062˚14.5436'W 286 m
Coralligorgia w. brittle stars. Subsamples: a: Brittle star in EtOH; b: Coralligorgia stalk, branches, and holdfast dried; c: Coralligorgia in EtOH; d: Coralligorgia in OGL vial #122

NA037-036-NB 2013/10/24 17:41 16°42.1855'N 062°14.5436'W 286 m
Water sample near end of dive for pH

NA037-037-ROVG 2013/10/24 22:27 16°36.6491'N 062°11.1884'W 836 m
Rock from start of boulder field, 10-cm wide, brown and black, angular/blocky, some soft tube encrustation. Grey hornblende-bearing, crystal-rich andesite w. 2 cm alteration rind

NA037-038-ROVG 2013/10/24 22:35 16°36.6510'N 062°11.1896'W 835 m
Black, more rounded rock, 10-cm long, several cm width, ~ 8 cm diameter, white tube encrustation. Reddish-oxidized andesite w. plag & minor hornblende

NA037-039-ROVG 2013/10/24 22:52 16°36.6429'N 062°11.1910'W 833 m
Black, rounded rock, ~10 cm long, gray hornblende-bearing andesite w. rusty manganese rind

NA037-040-ROVG 2013/10/24 23:00 16°36.6471'N 062°11.1930'W 830 m
Very oval, flat rock ~ 15 cm length, black, brittle star associate. Grey, slightly vesicular hornblende andesite w. 1-cm alteration rind. Subsamples: a: Rock; b: Brittlestar in EtOH

NA037-041-NB 2013/10/24 23:18 16°36.6508'N 062°11.2073'W 817 m
Water sample for pH. Avg. pH=7.8

NA037-042-ROVG 2013/10/24 23:37 16°36.6646'N 062°11.2158'W 820 m
Green-grey w. black crystals, shattered rock, fresh surface, prismatically jointed. Grey, dense, concoidally fractured, hornblende-bearing andesite

NA037-043-SL2013/10/25 00:20 16°36.7563'N 062°11.3837'W 843 m
Snails and polychaete associated with woodfall. Subsamples: a: polychaete tissue in OGL vial #113; b: Polychaete in EtOH; c: Gastropod tissue in OGL vial #112; d: gastropod tissue and shell in EtOH

NA037-044-ROVG 2013/10/25 01:54 16°36.9565'N 062°11.9186'W 818 m
Yellow-ish rock w. dark interior. Reddish brown volcaniclastic breccia w. some parts w. manganese crusts. Interior has greenish white soft mineral (sapolitic/smectite) hydrothermally altered material. Subsamples: a: rock; b: coral polyp OGL vial # 138

NA037-045-ROVG 2013/10/25 02:16°16°36.9630'N 062°11.9859'W 853 m
Large yellowish, angular rocks w. abundant bioencrustations. Angular block of grey, hornblende-bearing andesite w. manganese crust & bioencrustation

NA037-046-ROVG 2013/10/25 02:48 16°36.9903'N 062°12.1943'W 825 m
Reddish, black angular block. Oxidized, highly indurated volcaniclastic breccia w. some

calcareous veins. Abundant angular cm-sized lava clasts

NA037-047-ROVG 2013/10/26 18:25 16°35.9986'N 061°35.9986'W 885 m
Large, dark-colored rock, 10x40 cm, lots of bio encrustation. Manganese encrusted limestone (buff/brown) w. shell and coral fragments. Surface is porous with abundant worm tube casts. Subsamples: a: sponge OGL vial #129; b: coral or bryozoan, OGL vial # 120

NA037-048-NB 2013/10/26 20:38 16°36.2621'N 061°56.2886'W 784 m
Water sample in caldera near waypoint #12, pH analysis; pH: 7.77, 7.81, 7.82

NA037-049-ROVG 2013/10/26 21:00 16°36.2806'N 061°56.3354'W 801 m
Small, round, brown rock, diameter <10 cm, greenish-grey dense plag.-physic andesite w. some hornblende(?), slightly altered. Concave weathering on surface. Subsamples: a: rock; b: white sponge in EtOH

NA037-050-ROVG 2013/10/26 21:29 16°36.2795'N 061°56.3441'W 797 m
Thin, brown crust/matrix from rocky ridge, inside the crater. Reddish-brown volcaniclastic sandstone w. some lithic clasts. (Small clasts are highly oxidized). Some sponges on outside.

NA037-051-ROVG 2013/10/26 22:09 16°36.3397'N 061°56.3866'W 759 m
Rock from top of ridge in 1st caldera, lots of bioencrustation, ~15 cm long. Greenish-grey plag-bearing andesite w. concoidal weathering and manganese crust

NA037-052-ROVG 2013/10/27 00:35 16°37.1241'N 061°57.0617'W 616 m
Large, vesicle-rich clast w. some manganese coating

NA037-053-ROVG 2013/10/27 00:16 16°37.1061'N 061°57.0464'W 616 m
Slab of "basaltic" bubble rind, oxidized with some bio growth on surface

NA037-054-NB 2013/10/27 02:01 16°37.1150'N 061°57.0503'W 616 m
Water sample near vesicular boulder field, pH readings: 7.74, 7.80, 7.83

NA037-055-ROVG 2013/10/27 04:57 16°37.3160'N 061°57.4462'W 652 m
Small, angular black rock. ~15 cm. Lots of bio-encrustation: sponge, small branching white corals. Taken from base of large block w. unique texture (possible vesicles or weathering). Greenish-grey plag. Hornblende andesite w. complete manganese coating and bio orgs. Concoidally weathered surface

NA037-056-ROVG 2013/10/27 06:03 16°37.3491'N 061°57.5432'W 635 m
Bamboo octocoral- unknown species (Lepidisis?), yellow base, squat lobster. Subsamples: a: Squat lobster in EtOH, b: coral in EtOH; c: coral polyps OGL vial # 111

NA037-057 2013/10/27 08:51 16˚37.5764'N 061˚57.5010'W 666 m
Small piece of knobby brown concretion/crust. Very porous carbonate hardpan w. manganese crust

NA037-058-ROVG 2013/10/27 10:15 16˚37.6244'N 061˚57.4620'W 652 m
Loose black, ~10 cm angular rock from ridge. Buff grey hornblende-physic andesite. Concoidally weathered

NA037-059-ROVG 2013/10/28 07:33 15˚05.8072'N 061˚27.2423'W 2053 m
Small rock, black in color, 10x10 cm. Some bioencrustation. Taken near top of the 1st slope in the flat sediment area. Pyroxene/hornblende light grey decite w. manganese coasting and bioencrustations. (cm-sized oval slightly mafic inclusion is present near the manganese crust surface).

NA037-060-PC 2013/10/28 07:52 15˚05.7788'N 061˚27.2722'W 2051 m
sediment core. Only goes to duct tape—felt like solid rock below sediment layer. ~26-28 cm recovered. Some coarse sediment (black grains). Some small worms/polychaetes

NA037-061-ROVG 2013/10/28 08:54 15˚05.7594'N 061˚27.2742'W 2065 m
Ping pong sponge, white, Chondrocladia(?) w. polychaete worm/ Subsamples: a: Sponge in EtOH; b: polychaete worm in EtOH; c: 3x sponge balls in OGL vial 102; d: Polychaete tail in OGL vial: 103

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